

# Hard and Important

## The Challenges of Teaching (Physics) and What We Should Do To Improve It

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# My Path to This Conversation

BA → SA → CfA (MF) → MEd → WPCP → IMSA (CQ) → GA → CPS → PhD?



# Questions to Ponder

- Why are we still so clueless?

Our ignorance can be divided into problems and mysteries.

When we face a problem, we may not know its solution, but we have insight, increasing knowledge, and an inkling of what we are looking for. When we face a mystery, however, we can only stare in wonder and bewilderment, not knowing what an explanation would even look like.

-Chomsky

# Questions to Ponder

- How does a profession evolve?

*American Medical Education 100 Years after the Flexner Report:*

All forms of professional education share the goal of readying students for accomplished and responsible practice in service to others. Thus, professionals in training must master both abundant theory and large bodies of knowledge; the final test of their efforts, however, will be not what they know but what they do.

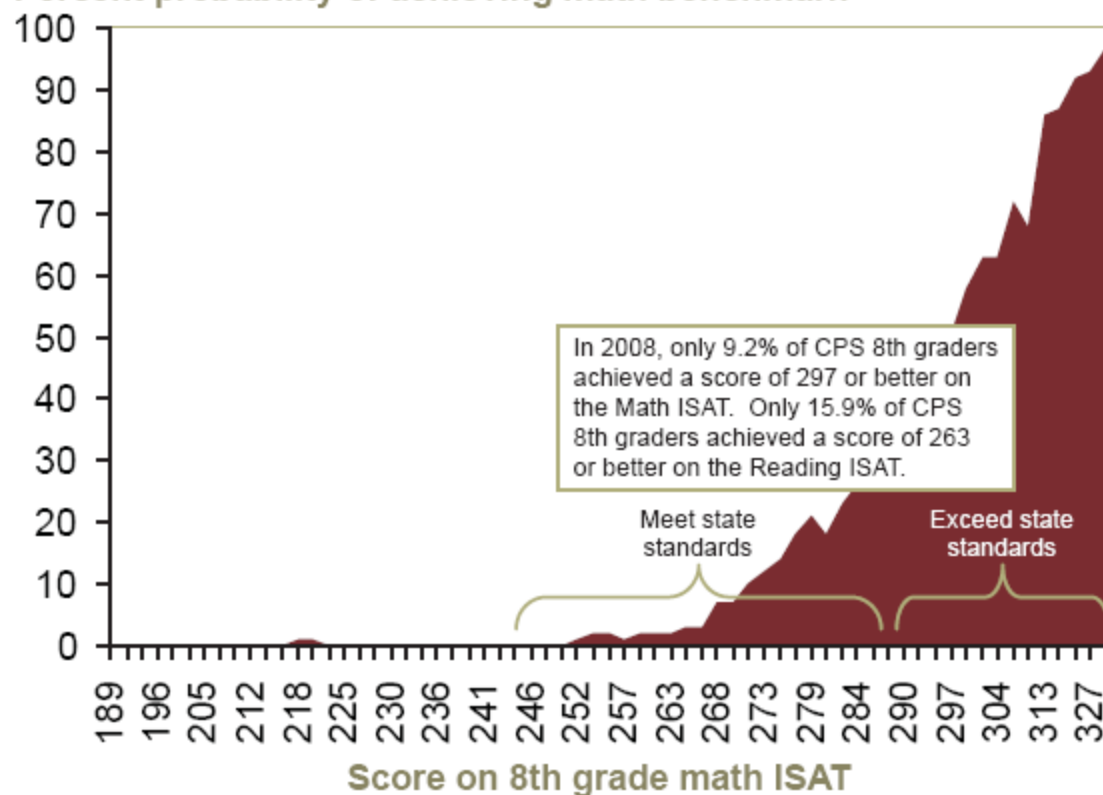
Cognitive psychology has demonstrated that facts and concepts are best recalled and put into service when they are taught, practiced, and assessed in the context in which they will be used.

# Questions to Ponder

- Why are we still so clueless?
  - From Mysteries to Problems
- How does a profession evolve?
  - From Problem-Constrained to Problem-Driven
- How do we reconcile the successes of physics research with the failures of (physics) education?

## PROBABILITY OF REACHING COLLEGE READINESS ON MATH ACT (Based on score on the 8th grade math ISAT)

Percent probability of achieving math benchmark



By comparing the scores of CPS 8th graders who took the Math ISAT in 2004 to their scores on the Math ACT in 2007, we can estimate the probability of achieving the college readiness benchmark on the ACT given a student's score on the ISAT.

To have a 50/50 chance of reaching the college readiness benchmark ACT score in 11th grade, 8th graders must score 297 on the Math ISAT (and 263 on the Reading ISAT). Students who only meet State standards have a low probability of reaching these benchmarks.

Source: Analysis from the Consortium on Chicago School Research

# 2009 CPS AP Participation

	Number of AP Test Takers (and As Percentages of Entire CPS HS Subgroup Enrollments, incl. Charter)								
Subgroup (w/ CPS HS Enrollment)	Stats	Calc AB	Calc BC	Bio	Chem	Env Sci	Phys B	Phys C Mech	Phys C E&M
White (9,817)	137 (1.40)	160 (1.63)	55 (0.56)	179 (1.82)	120 (1.22)	101 (1.03)	90 (0.92)	18 (0.18)	18 (0.18)
Asian (4,338)	126 (2.90)	211 (4.86)	56 (1.29)	165 (3.80)	153 (3.53)	101 (2.33)	103 (2.37)	21 (0.48)	19 (0.44)
Black (59,089)	293 (0.50)	223 (0.38)	7 (0.01)	270 (0.46)	122 (0.21)	183 (0.31)	82 (0.14)	17 (0.03)	4 (0.01)
Chicano (23,228*)	184 (0.79)	239 (1.03)	16 (0.07)	242 (1.04)	111 (0.48)	95 (0.41)	72 (0.31)	5 (0.02)	5 (0.02)
Puerto Rican (4142*)	39 (0.94)	34 (0.82)	3 (0.07)	58 (1.40)	17 (0.41)	18 (0.43)	15 (0.36)	1 (0.02)	1 (0.02)
Native American (197)	2 (1.02)	1 (0.51)	0 (0.00)	4 (2.03)	1 (0.51)	2 (1.02)	1 (0.51)	0 (0.00)	0 (0.00)

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\* Initial enrollment estimates based on 2008 Racial Ethnic Survey data; %s likely larger than actual

# 2009 CPS AP Participation Summary

- AP participation varies by subgroup by  $> 10 \times$
- In AP Calculus and Physical Sciences
  - more than 6% of Asian CPS students took them
  - compared to less than 0.4% of Black CPS students



# 2009 CPS AP Performance

	Mean Score (on a scale from 1 to 5)								
	Stats	Calc AB	Calc BC	Bio	Chem	Env Sci	Phys B	Phys C Mech	Phys C E&M
White	3.2	2.6	3.9	2.8	2.5	2.7	2.4	3.2	3.1
Asian	2.8	2.4	3.6	2.6	2.3	2.3	2.3	3.5	3.1
Black	1.2	1.3	2.4	1.2	1.3	1.3	1.3	1.7	3.3
Chicano	1.4	1.4	2.6	1.3	1.6	1.6	1.4	3	3.2
Puerto Rican	1.5	1.5	2.3	1.4	1.4	1.4	1.3	4.0	2.0
Native American	3.0	3.0	--	1.5	1.0	1.0	1.0	--	--

# Clarifying What We Mean By...

## “Hard”

- Multi-dimensional
  - Several inputs
- Cognitively Complex
  - Not obvious
- Process-Dependent
- Hidden

Some of the best teaching is indirect.... This process is inaccessible to direct observation by an outside person in the same way as our internal bodily processes are to a medical practitioner. In both these cases, a person who intervenes without an adequate mental image of what is going on inside is as likely to do harm as good.

-Richard R. Skemp

*The Psychology of Learning Mathematics*

# Clarifying What We Mean By...

## “Hard”

- Multi-dimensional
  - Several inputs
- Cognitively Complex
  - Not obvious
- Process-Dependent
- Hidden
- Important/High-Stakes

## “Important”

- Lives Depend on It
  - Combats Financial Poverty
  - Combats Intellectual Poverty

# The Astronaut and the Teacher:

## Training Appropriate for the Task



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# In Problem-Driven Professions...

- Agreement About What the Problems Are
- Clearly Defined Terms
- Communication Between Researchers and Practitioners

# How Do We Get There From Here?



# *The Strategy*

“We have the opportunity to become the premier urban district.”

Dr. Barbara Eason-Watkins  
CPS Chief Education Officer

- Achievement Strategy—Building the Foundation
- Advancement Strategy—Nurturing Excellence



# *Project Goals and Audiences*

To design and execute a program that demonstrates:

(1) Training teachers as collaborative problem solvers will transform teaching into a problem-driven rather than problem-limited profession.

- Middle and High School Teachers

- Committed core

(2) Excellent scholarship by underrepresented students in math and science is a necessary component and catalyst of our success.

- Entering 6<sup>th</sup> to entering 12<sup>th</sup> graders

- Students of high need and potential

# Summer Component

Summers Before Each Grade Level	Seven-Year Student Growth Plan	Four- to Five-Year (min) Teacher Growth Plan	Teacher Proficiency Level
6 <sup>th</sup> 7 <sup>th</sup>	<ul style="list-style-type: none"> <li>• Pre-Algebra</li> <li>• Intro to scientific inquiry</li> </ul>	<ul style="list-style-type: none"> <li>• Obtain endorsements from partner universities</li> <li>• Attend summer teacher session for graduate credit</li> <li>• Assist and co-teach summer student session</li> <li>• Receive academic year coaching</li> </ul>	Fellow (1 yr as needed)
8 <sup>th</sup> 9 <sup>th</sup>	<ul style="list-style-type: none"> <li>• Algebra and proportional reasoning</li> <li>• Intro to experimental design</li> <li>• College visits</li> </ul>	<ul style="list-style-type: none"> <li>• Attend summer teacher sessions for grad credit</li> <li>• Co-teach summer student session</li> <li>• Participate in academic year teaming</li> <li>• Continue optional graduate level courses</li> <li>• Participate in one optional “sabbatical summer” of lab research</li> </ul>	Resident (3 yr min)
10 <sup>th</sup> 11 <sup>th</sup> 12 <sup>th</sup>	<ul style="list-style-type: none"> <li>• Math and science leading to AP-level calculus and science course</li> <li>• Grade 11 summer living on university campus</li> <li>• Grade 12 summer research fellowship</li> </ul>	<ul style="list-style-type: none"> <li>• Co-plan and teach teacher summer sessions</li> <li>• Direct student summer research internships</li> <li>• Provide academic year mentorship</li> </ul>	(1 yr min)

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# Enrollment

Enrollment Targets	<i>Students</i>	<i>Teachers</i>
	<ul style="list-style-type: none"><li>• Two 30-student classrooms at each grade level</li><li>• 60 students per grade level</li></ul>	<ul style="list-style-type: none"><li>• 4 teachers and 1 mentor per classroom</li><li>• 8 teachers + 2 mentors per grade level</li></ul>

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Operation Year 1—2011  
Grades 6 & 9

- 120 students

- 16 teachers + 4 mentors

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• 120 students	• 16 teachers + 4 mentors
Operation Year 2—2012 Grades 6, 7, 9, 10	
• 240 students	• 32 teachers + 8 mentors



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• 360 students	• 48 teachers + 12 mentors

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	Operation Year 3—2013 Grades 6 – 11	
	• 360 students	• 48 teachers + 12 mentors
	Operation Years 4+—2014 onward Grades 6 – 12	
	• 420 students	• 56 teachers + 14 mentors

# Summer Institute Principles and Outcomes, 1

<i>Guiding Principles</i>		<i>Desired Outcomes</i>
<ul style="list-style-type: none"> <li>• Successful math and science instruction in CPS requires a <b>committed core</b> of outstanding teachers and students throughout the district whose efforts produce exceptional scholarly achievement.</li> </ul>	→	<ul style="list-style-type: none"> <li>• Student scholarship and teacher practice will provide a model of excellence within the district by advancing math, science, and urban education nationally.</li> <li>• Teachers will demonstrate the ability to teach honors and college-level subjects for understanding.</li> <li>• Participating students will demonstrate college readiness by earning a 3 or better in AP Calculus and in one or more AP science courses during or before their senior year.</li> </ul>
<ul style="list-style-type: none"> <li>• Improving math and science instruction requires nurturing that “committed core.”</li> </ul>	→	<ul style="list-style-type: none"> <li>• Summer residencies will give teachers ongoing, collaborative, in-the-field professional growth.</li> <li>• CPS and its partners will create a network of science and math teachers supported by regular meetings and online resources serving new and experienced teachers.</li> <li>• CPS students will receive academic-year supports through individual and group study sessions supporting a growing peer group.</li> </ul>

# Summer Institute Principles and Outcomes, 2

<i>Guiding Principles</i>		<i>Desired Outcomes</i>
<ul style="list-style-type: none"> <li>• Learning for understanding is significantly different from learning to acquire information, differing both in method and outcome.</li> </ul>	→	<ul style="list-style-type: none"> <li>• The lessons prepared by teachers and the problems solved by students will reflect their ability to make new connections, an essential indicator of understanding.</li> </ul>
<ul style="list-style-type: none"> <li>• A teacher's ability to implement and design experiences that lead students to construct their own understanding is an essential skill of rigorous instruction.</li> </ul>	→	<ul style="list-style-type: none"> <li>• Teachers and their mentors will collaboratively modify and create a curriculum supporting students' efforts to construct novel intellectual connections.</li> </ul>
<ul style="list-style-type: none"> <li>• Although intellectual poverty is a greater obstacle to students' future development than financial poverty, students' intellectual potential will be more fully realized as their basic financial needs are met.</li> </ul>	→	<ul style="list-style-type: none"> <li>• Student and teacher pay and aggressive promotion of learning for understanding will result in greater than 90% student retention from the summer before 6<sup>th</sup> grade to the summer before 12<sup>th</sup> grade, excluding transfers out of CPS.</li> <li>• A significant positive shift in math and science attitudes and achievement will be observed relative to non-participant peers.</li> </ul>

# Another Model—Lesson Study

- A strategy for collaborative problem-solving:
  1. Team develops the research lesson
  2. Live research lesson w/ one teacher, many observers
  3. Post-lesson discussion w/ teacher-researchers and observers

# So What's the Big Idea?

- Even the best teachers in the best classrooms will encounter problems they can't solve alone.
  - i.e. Teaching is hard.
- Problems should be a source of progress, not the barrier thereto.
- The training should suit the difficulty and importance of the task.

# Thank you, Chris!



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